

# Recanalization of totally occluded iliac and adjacent venous segments

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**Purpose:** The purpose of this study was to report our experience with percutaneous recanalization of totally occluded iliac veins and inferior vena cava.

**Material and Methods:** Recanalization of the iliac vein was performed in 38 limbs. In nine limbs, recanalization of the inferior vena cava was also necessary (two with filter). In 28 of 38 limbs, the stent was extended below the groin crease into the common femoral vein segment. Large-caliber (14 or 16 mm for iliac vein) flexible self-expanding stents were used. Stents were routinely extended for a short distance into the inferior vena cava to forestall development of ilio caval stenosis. Intravascular ultrasound scan was a valuable tool in the procedure. The median length of the recanalized segment was long (22 cm), and multiple stents (median,  $n = 3$ ) were necessary in most patients. Forty-five percent of the patients had coagulation abnormalities.

**Results:** No morbidity or mortality was seen. Actuarial primary, primary assisted, and secondary patency rates of the stents at 24 months were 49%, 62%, and 76%, respectively. Median pain level decreased significantly (level 4 to level 0;  $P < .0001$ ) after stent placement, and more than two thirds of the patients became totally pain free after the procedure. Swelling also improved significantly, and a third of the patients became totally free of any swelling after stent placement. Sixty-six percent of cases with stasis ulcers/dermatitis ( $n = 14$ ) were resolved (actuarial, 1 year), although uncorrected reflux persisted in many of these limbs.

**Conclusion:** Percutaneous recanalization of the occluded iliac vein with stent placement appears to be successful in the short term, with good patency, significant symptom resolution, and minimal morbidity. (*J Vasc Surg* 2002;36:903-11.)

Stenotic lesions of the iliac venous segment can be successfully treated with percutaneous balloon dilation and stent placement.<sup>1</sup> Excellent short-term patency and clinical efficacy rates have been reported.<sup>2</sup> This report describes our experience with recanalization of totally occluded iliac veins and adjoining venous segments with the percutaneous balloon/stent technique.

## MATERIAL AND METHODS

Recanalization was performed in 38 postthrombotic limbs in 38 patients from July 1997 to October 2001. In two patients, bilateral stent placement was carried out to recanalize an ipsilateral iliac venous segment and correct a stenotic but nonoccluded lesion in the contralateral iliac venous segment as well. In nine patients, the adjoining inferior vena cava, which was occluded (two with filters) in continuity with the iliac venous segment, was recanalized also. In 28 limbs, the stent was extended below the inguinal ligament to correct occlusion/stenosis of the common femoral vein segment in continuity with the occluded iliac vein. Median age was 44 years (range, 27 to 81 years), the left/right ratio was 5/3, and the female/male ratio was 3/1.

Most limbs (88%) had significant additional venographic postthrombotic changes (diffuse narrowing, trabeculae, or occlusions) in the distal venous tree; in only 12% did the main iliac or iliofemoral occlusion appear to be isolated with "normal" appearing veins below the lesion. Distal postthrombotic changes were typically diffuse and extensive, involving all three distal axial venous segments (superficial femoral, popliteal, posterior tibial) in 62%, two segments in 29%, and a single segment in only 9%. The profunda femoris vein showed venographic postthrombotic changes in 42% of limbs treated, and when this condition occurred, it was exclusively associated with multisegment distal postthrombotic changes.

Separate from the main iliac or iliofemoral occlusion, additional tandem total occlusions in the superficial femoral, popliteal, or posterior tibial veins were present in 52% of limbs. Seventy-seven percent of such tandem occlusions involved only one distal venous segment and most commonly occurred (70%) in the superficial femoral vein. Distal tandem occlusions were not recanalized.

Reflux with duplex scan examination was present in 87% of the ipsilateral extremities, and in only 13% was no reflux seen. When present, reflux was confined to the superficial venous system alone in 12%, the deep system alone in 23%, and both the superficial and deep systems in the remaining 65% of involved limbs. Reflux was not corrected in the recanalized limbs.

**Clinical evaluation.** All patients had various combinations of leg pain, swelling, and skin changes (Table I). The median duration of symptoms at presentation was 7 years (range, 2 months to 40 years). CEAP classification<sup>3</sup> of the clinical material was as follows: C0,  $n = 3$  (pain only symptom); C3,  $n = 19$ ; C4,  $n = 2$ ; C5,  $n = 0$ ; and C6,  $n =$

From the University of Mississippi Medical Center and River Oaks Hospital. Competition of interest: nil.

Presented at the Fourteenth Annual Meeting of the American Venous Forum, La Jolla, Calif, Feb 21-24, 2002.

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0741-5214/2002/\$35.00 + 0 24/6/128635

doi:10.1067/mva.2002.128635

**Table I.** Presenting symptoms in 38 limbs with iliac vein occlusion

<i>Symptom/combination</i>	<i>No.</i>
Pain only	3
Swelling only	5
Pain and swelling	14
Ulcer/stasis skin changes only	12
Pain and stasis skin changes/ulcer	2
Pain, swelling, and stasis skin changes/ulcer	2

14, with active ulcers present. Pain, often severe, was a common form of primary presentation. Pain was present in 89% of the limbs.

The level of pain was measured with the visual analogue scale method.<sup>4</sup> A commonly available plastic tape measure with markings on only one side trimmed to 10 cm in length was used. The patient was asked to indicate the pain level on the unmarked side of the device, with one end representing no pain and the other extreme pain. The indicated pain level could then be translated into numeric grade (0 to 10) by the examiner with referral to the scale markings on the side hidden to the patient. Patients were asked to fill out a quality of life questionnaire<sup>5</sup> validated for assessment of chronic venous insufficiency prospectively before recanalization and again at each subsequent postoperative visit. Numerical grades (1 to 5) were provided for each question, allowing the patient to assign a numeric value to the answers. The last available response was used in postoperative outcome analysis. Swelling was graded with physical examination as follows: grade 0, none; grade 1, pitting, not obvious; grade 2, ankle edema; and grade 3, obvious swelling involving the limb.

**Preoperative assessment.** Preoperative assessment included hypercoagulation studies, extensive hemodynamic and duplex scan examination (Table II), and contrast ascending and transfemoral venography. Foot swelling or extension of the occlusive lesion to the femoral venous segment precluded one or more of these studies in some patients. In such cases, contralateral femoral approach was attempted to define the occlusive lesion.

**Intraoperative functional assessment.** Base femoral venous pressure, pressure gradient, and increase in femoral vein pressure in response to 30 mg of papaverine hydrochloride injected into the adjoining femoral artery<sup>6</sup> with ultrasound scan guidance were measured before and after recanalization.

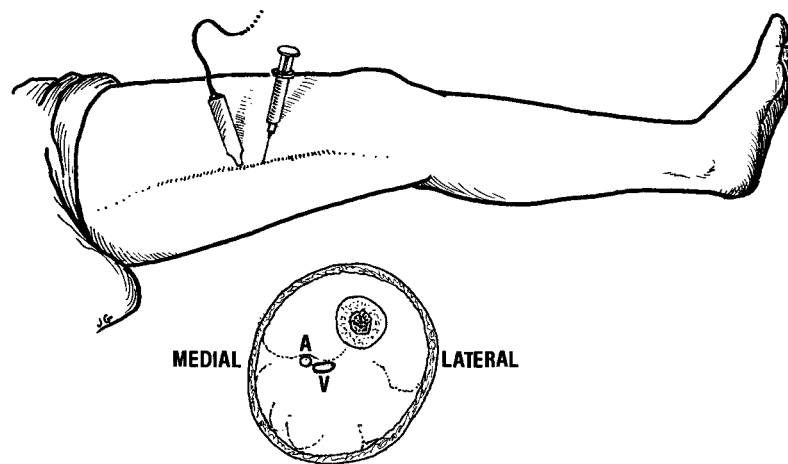
**Postoperative assessment.** Postoperative assessment included clinical evaluation (at 6 weeks and 3-month to 6-month intervals thereafter), transfemoral or ascending venogram (latter in case of infrainguinal stent extension) to assess stent patency, duplex scan, and venous functional studies (at 6 weeks and yearly thereafter; sooner if warranted by clinical deterioration). Intravascular ultrasound scan (IVUS) was often combined with transfemoral venography when secondary interventions were anticipated.

**Technique.** The procedure was performed in an endovascular surgical suite. General anesthesia was preferred

because the recanalization process was often painful and sometimes prolonged; it provided superior comfort and safety, particularly in elderly patients with diminished cardiopulmonary reserve. Ipsilateral percutaneous femoral vein access through a 9F sheath after needle exchange over guidewire (Glidewire, Terumo Medical, Ann Arbor, Mich; 0.035 in) was obtained with ultrasound scan guidance (Fig 1). Thigh access was more convenient and allowed better maneuverability of instrumentation through the occlusion than the popliteal approach. Use of a stiff guidewire and predilation with serial dilators facilitated sheath placement in case of perivenous fibrosis. Puncture site hematoma/bleeding after sheath removal has not been a problem (common in arterial access) because of the relatively low pressure on the venous side and the routine use of tamponade devices (Vasoseal, Datascope Corp, Montvale, NJ).

An initial contrast study and a "road map" were used to manipulate the guidewire beyond the point of occlusion. Guidewire manipulation was by both sight (road map) and feel; as the guidewire progressed, repeat contrast studies were obtained as necessary, with sensitivity to the total amount of contrast used. A combination of soft and stiff Glidewires with straight, angled, and "J" tips and differing sizes (0.016 in to 0.035 in) with supporting catheters (straight or angled) were often necessary for successful passage of the occluded segments. Once the correct plane was entered, rapid progress without perforation could be obtained with development of a loop or extended J at end of a stiff guidewire during manipulation. Whenever a perforation was detected with free lateral movement of the guidewire tip or contrast extravasation, the procedure was terminated and attempted again 3 to 4 weeks later. If difficulty was encountered in onward passage, manipulation of the guidewire through a collateral running parallel to the occluded segment could be attempted. Passage through the occluded ilio caval junction usually met with additional resistance that necessitated extended manipulation in the area with coaxial catheter support. Specialized techniques, such as those described to cross the occluded aortoiliac junction, were not used.<sup>7</sup>

Successful vena cava entry was indicated by further easy passage of the guidewire into the right atrium and was confirmed with IVUS or contrast injection. Serial progressive dilations to 16 mm for the distal cava and common iliac veins, to 14 mm for the external iliac vein, and 12 mm for the common femoral vein were chosen for most cases. Extension of the stent into the distal vena cava for 2 to 3 cm or even longer as determined with IVUS was routine to avoid later stenotic development in this area.<sup>8</sup> Skip areas of less than 4 cm in length between stents were avoided even if this segment was patent because stenotic lesions tended to occur later in these areas as well. All diseased or occluded segments were covered, going below the inguinal ligament if necessary. The profunda femoris vein was easily identified with IVUS, and extension of the stent across the groin crease into the common femoral vein just above the profunda orifice was not found to jeopardize stent patency; on the contrary, failure to support the diseased common fem-



**Fig 1.** Femoral vein access is obtained as low as possible in thigh. With access at higher levels, sheath length should be kept to minimum to allow stent delivery into common femoral vein if desired. Ultrasound scan guidance is necessary because vessels are deep and vein has variable relationship to artery depending on level of entry. When superficial femoral vein is occluded, profunda femoris or deep thigh collateral may be accessed.

**Table II.** Functional studies before and after recanalization and stent placement

Test	Present		Poststent	
	No.	Median (range)	No.	Median (range)
Intraoperative pressure measurements				
Femoral base pressure (mm Hg)	31	12 (3-27)	30	10 (3-21) <sup>†</sup>
Pressure gradient (mm Hg)	27	2 (5-9)	26	0 (0-84) <sup>†</sup>
Pressure increase with intraarterial papavarin (mm Hg) <sup>6</sup>	28	3 (1-14)	29	0 (1-10) <sup>‡</sup>
Postoperative tests				
Ambulatory venous pressure				
Percent drop (mm Hg)	30	60 (30-93)	16	60 (24-97)*
VFT (seconds)	31	18 (3-136)	14	21 (5-132)*
Arm-foot pressure differential test (mm Hg)	31	1 (0-7)	16	1 (0-8)*
Reactive hyperemia (mm Hg)	30	5 (0-16)	15	6 (2-20)*
Obstruction grade	33	1 (1-4)	18	1 (1-4)*
Airplethysmography				
VFI <sub>90</sub> (mL/min)	34	2.4 (0.9-11.9)	16	2.0 (0.1-7.2)*
Venous volume (mL)	33	67 (26-308)	17	77 (26-135)*
Ejection fraction (%)	33	57 (14-100)	17	41 (17-100)*
Residual volume fraction (%)	33	35 (0-82)	17	38 (0-100)*
Duplex scan examination				
Multisegment reflux score <sup>12</sup>	36	2.5 (0-4)	18	2 (0-4)*
Descending venography				
Kistner reflux grade <sup>12</sup>	36	0 (0-4)	18	0.5 (0-4)*

\*P = not significant.

<sup>†</sup>P < .01.

<sup>‡</sup>P < .001.

oral segment with a stent resulted in thrombosis of the stent from poor inflow.

Stent deployment was mandatory in treatment of venous stenosis because balloon dilatation alone resulted in invariable recoil<sup>9</sup> and restenosis. We did not place stents in the superficial femoral vein because the profunda femoris appeared to provide adequate inflow. Self-expanding stents (Wallstent, Boston Scientific, Natick, Mass) were used ex-

clusively. The lengths of the individual stents were chosen to minimize the overall number of stents deployed, allowing for a generous overlap of 3 to 4 cm between stents to avoid stent separation during postdeployment dilation. Proximal migration of the stent crossing the tight ilioacaval junction could occur during this phase if adequate predilatation with oversized balloons when necessary was not achieved. "Shelving" between stents of different sizes (eg,

16 mm to 14 mm) could be avoided with the larger sized stent to cover the entire length but dilate the smaller luminal area with a balloon of appropriate smaller size.

A completion venogram was performed to assess in-flow, flow velocity, outflow, and collateral status. IVUS examination was an invaluable tool during all phases of the procedure to confirm the nature and extent of present pathology; to identify webs, membranes, and trabeculae that could be masked in venography; to gauge transmural changes to aid extension of the stent into normal areas at either end; and to detect technical defects in stent deployment, such as shelving, separation, incomplete expansion, and intrastent defects, such as flaps and thrombi. IVUS was superior to venography in all these areas<sup>8-10</sup> and reduced the overall contrast load.

**Perioperative anticoagulation therapy.** Patients on warfarin therapy were instructed to stop the medication 2 days before the intervention, and it was restarted again the same day after the procedure. A preoperative international normalized ratio of up to 2.7 was no contraindication to the procedure. Dalteparin sodium (5000 units) was given twice daily subcutaneously for 36 to 48 hours starting at the time of preoperative sedation. Intravenous heparin (2000 to 5000 units) was administered after placement of the sheath in the femoral vein. A synthetic nonsteroidal preparation (Toradol, American Regent Laboratory, Shirley, NY; 30 mg) was given at the time of recanalization and continued at 8 hourly intervals until discharge the next day. In recent cases not included in this series, the latter drug was replaced by IIb/IIIa platelet inhibitor (abciximab; 15 mg) given as a slow bolus intravenously at the time of recanalization. All patients were discharged with aspirin (81 mg) therapy daily or twice weekly if they were receiving warfarin as well. Patients with homocystinemia (three patients) were placed on aspirin, vitamin B6, and folate therapy but not warfarin therapy. Warfarin therapy was instituted/reinstituted in all cases of thrombophilia (14 patients) and recurrent thromboembolism (six patients) and for other indications (two patients).

**Data collection and statistics.** Clinical data were entered prospectively into a time-stamped electronic medical records program and analyzed later. Nonparametric Wilcoxin rank test for paired data,  $\chi^2$  analysis, and actuarial curves (Kaplan-Meier) were used for statistical analysis as appropriate. A commercially available statistical program (Graph Pad Prism for Windows, version 3.0, GraphPad Software, San Diego, Calif) was used for analysis.

## RESULTS

Eight technical failures (8/46 limbs or 13%) occurred and are excluded from the analysis presented here; their clinical status remained unchanged after the failed attempt. Five of these eight had closed or open prior interventions/trauma of the occluded segment (two failed Palma bypasses, two caval filter placements, one previous chronic self drug administration). However, seven other limbs with prior surgical intervention in the area were successfully recanalized and are included in the series, indicating that

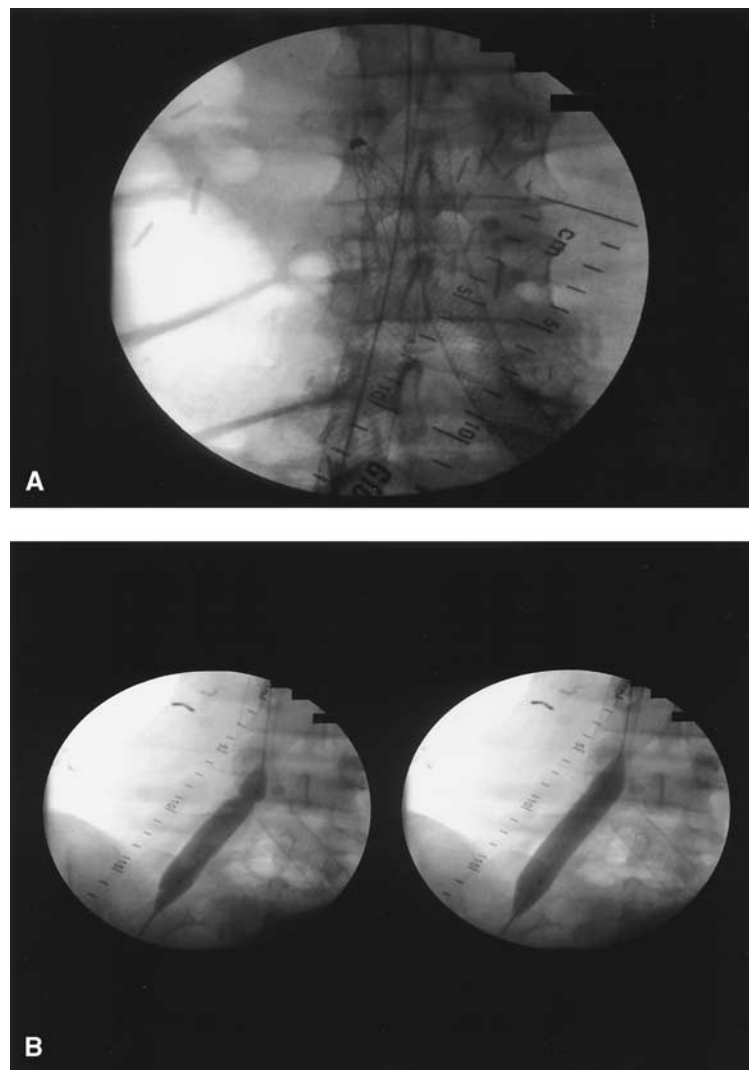
prior interventions diminished but did not preclude technical success. Among the 38 limbs included here, four (4/38; 11%) had unsuccessful first attempt at recanalization but had technical successes during subsequent attempts (one on the third attempt), indicating that repeat attempts in case of initial failure are worthwhile. No procedure-related mortality or morbidity was seen. Mild to moderate back pain for a few days after the procedure was frequent and was readily controlled with nonnarcotic analgesics in most patients. No infections or thromboses were noted in connection with the use of extraluminal tamponade device (Vasoseal).

Seventeen patients (45%) in this series had identifiable hypercoagulable abnormalities: antithrombin III deficiency in one patient, protein C deficiency in one patient, protein S deficiency in one patient, both protein C and S deficiency in two patients, factor V mutation in four patients, both factor V and prothrombin mutations in one patient, lupus anticoagulant in two patients, immunoglobulin M anticardiolipin antibody in one patient, immunoglobulin G anticardiolipin antibody in one patient, homocystinemia in one patient, and homocystinemia with abnormal homocysteine gene in two patients. No correlation was seen between stent patency and hypercoagulability. The median recanalized segment length was nearly a foot long; median length of stents was 22 cm (range, 2 to 27 cm). Multiple stents were necessary in most limbs (36/38; median, 3; range, 1 to 6).

The stent was extended into the vena cava in all but one limb in this series. In nine of 38 patients, the stent extended well into the vena cava because the inferior vena cava segment was occluded in continuity with the iliac vein; in two of these cases, previously placed filters were pushed aside with balloon dilation and a stent was placed astride (Fig 2). In two limbs, the entire vena cava was occluded and the stent extended to the right atrium (Fig 3). No adverse renal or visceral outflow problems were noted in these cases. In 28 limbs, the stent was extended for a short distance into the inferior vena cava for technical reasons (see Technique section); in only one of 38 limbs was the stent not extended into the vena cava because the occlusive lesion was confined to the external iliac vein.

In most limbs (74% or 28/38 limbs), the stent had to be extended below the inguinal ligament to support a stenotic/occluded common femoral vein segment. Stent patency appeared to be unrelated to crossing the groin crease; however, the overall number of occluded stents in this series ( $n = 7$ ) was too small to draw valid conclusions regarding these and other factors mentioned previously that could affect stent patency.

Collaterals were documented in 36 of 38 limbs on table preprocedure venography. After balloon dilation and stent placement, collaterals had disappeared in 33 cases (Fig 4), indicating that the stents had provided a lower resistance alternative pathway for venous outflow; collaterals were less prominent in the remaining three. Intraoperative pressure measurements were significantly improved after recanalization (Table II). Base femoral vein pressure, pressure gradient, and femoral vein pressure increase with papaverine



**Fig 2.** **A,** When stent is extended into vena cava during recanalization, stent in contralateral limb can be placed side by side in cava if there is room. Note Greenfield filter encased in occluded caval segment that was pushed aside with balloon dilation during recanalization. Progressive dilatation was necessary to break cicatrix encasing filter. Balloon puncture, although it occurred during this maneuver, was not a major problem. **B,** Alternative technique of fenestration of previously placed stent in vena cava with balloon to configure two stents in form of inverted "Y." This technique may be used when enough room in cava is not present to place two stents side by side.

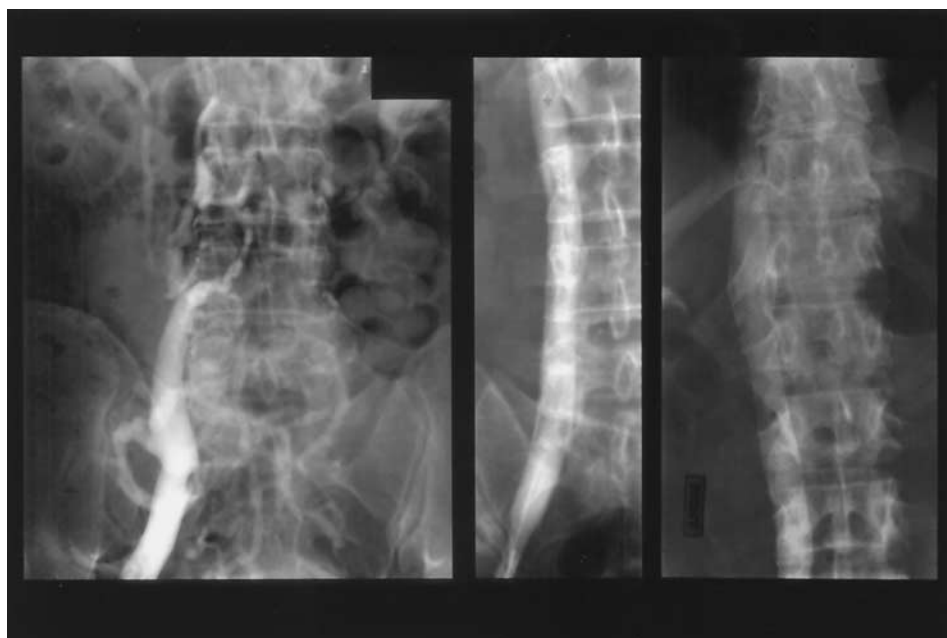
hydrochloride<sup>6</sup> each improved at least 3 mm Hg or more after stent placement in 11/29, 11/23, and 10/27 limbs, respectively. Postoperative functional tests, however, failed to reflect these hemodynamic improvements (Table II).

Venographic follow-up was obtained in 29 of 38 patients at a median of 4 months (range, 2 to 23 months) after recanalization. Two early (<30 days) occlusions and five late occlusions occurred. Thrombolysis was attempted but failed in one of the two early occlusions. The two stents deployed bestride a previous caval filter in two limbs were venographically patent at 5 months and 1 year. Two patients with extension of the stent to the right atrium also

have maintained patency per venogram at 4 months and 1 year. Eight of a total of nine caval stents placed for recanalization of abdominal vena cava were patent at follow-up venography; the single patient with the occluded caval stent in this category had surprisingly minimal symptoms after stent closure.

Among the 22 patent stents, preventive interventions were undertaken in four cases (three symptomatic, one asymptomatic) to correct partial thrombus/intimal hyperplasia in three limbs and stenosis distal to the stent in one limb, respectively. Actuarial venographic primary, assisted primary, and secondary patency rates (49%, 62%, and 76%,





**Fig 3.** Entire abdominal inferior vena that was occluded in continuity with common iliac vein was recanalized with stent extending up to right atrium. No visceral or renal compromise was noted before or after stent placement, with follow-up now extending more than 1 year.

respectively) at 24 months are shown in Fig 5. Clinical follow-up was available in 32 of 38 patients (median, 11 months; range, 1 to 42 months).

Median pain level decreased significantly ( $P < .0001$ ) from a median preoperative level of 4 (range, 0 to 9) to a postoperative level of 0 (range, 0 to 8) on the visual analogue scale. Pain was a near universal feature before surgery; only four of 32 or 11% had no pain. Most of the patients (24/32 or 75%) were completely relieved of pain after stent placement ( $P < .002$ ).

Swelling decreased significantly ( $P < .004$ ) from a median preoperative clinical grade of 1 (range, 0 to 3) to a postoperative grade of 0 (range, 0 to 3). No swelling was seen in 22% (8/32) before surgery, which increased to 52% (17/32) after surgery; this was significant ( $P < .02$ ).

**Stasis dermatitis/ulcers.** Follow-up was available in 14 of 16 limbs with preoperative active ulcers (12/14) or stasis dermatitis (2/2). Seven of 12 ulcers had healed, three improved, and two were unchanged. The two limbs with stasis dermatitis resolved. Actuarial complete healing of stasis ulcers/dermatitis at 12 months was 66%.

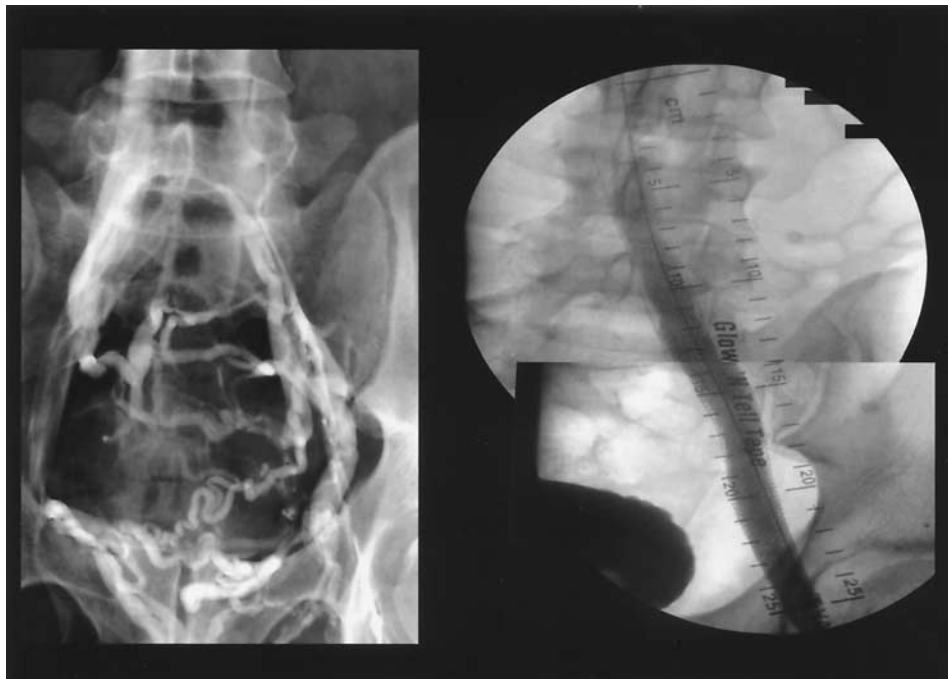
**Quality of life.** Significant improvement was seen ( $n = 26$ ) in pain ( $P < .002$ ) and sleep criteria ( $P < .02$ ), nonsignificant improvement was seen in work ( $P < .07$ , not significant; 12 patients were retired for age before stent), and no improvement was seen in morale and social activities.

## DISCUSSION

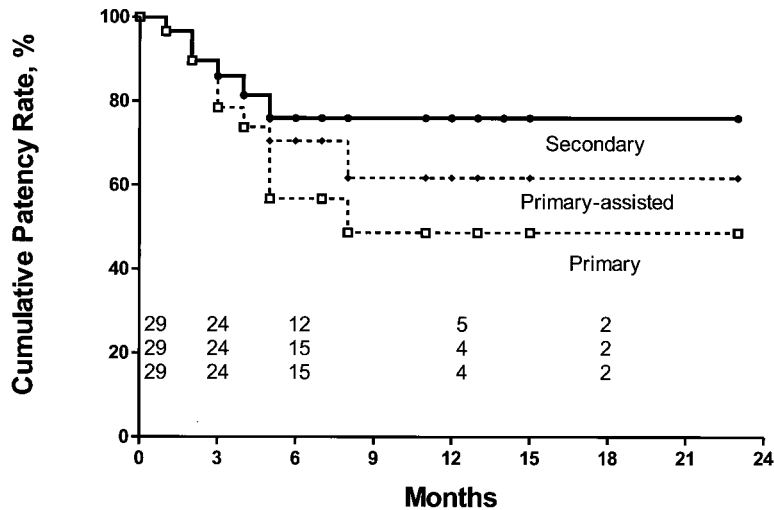
Even for a short-term follow-up study, the patency rate of recanalized previously occluded segments is remarkable,

given the circumstances widely perceived to be adverse to stent patency: the long length of recanalized segments, extension below the inguinal ligament in most patients, the high incidence rate of hypercoagulability in the study cohort, and the use of minimal antithrombotic measures in others. Despite common usage of terminology suggesting nontraumatic correction ("angioplasty"), balloon dilation of occluded segments remains a crude and uncontrolled technique with likely fracture of the fibrous cord replacing the thrombosed vein. Undoubtedly, some portions of the stent were exposed bare in the retroperitoneum through channel fractures. Yet there was no detectable retroperitoneal bleeding and the patency rate was high. Details of the reparative process with retention of stent patency in such a high proportion of patients remain unknown. Biologic compatibility of the stent material probably plays a significant role. The use of an adjunctive arteriovenous fistula with its potential for distal venous hypertension would seem to be unnecessary given the high stent patency rate without it.

Some technical points that we considered important from our experience differ from current practice elsewhere and are of note. The thigh approach with ultrasound scan guidance has been associated with low access-related complications in our experience ( $<1\%$ ;  $n = 525$ ). We considered either 14 or 16 mm the optimal size for stents to be placed in the iliac system. This was based on the normal size of the healthy adult vein, the frequent occlusion of smaller (12 or 10 mm) stents placed in the area by others in our own institution, and the belief that the implant size should



**Fig 4.** Collaterals disappeared on contrast venography after recanalization in 33 of 36 limbs. An example is shown above.



**Fig 5.** Actuarial primary (49%), assisted primary (62%), and secondary (76%) patency rates of stents after recanalization at 2 years. Limbs at risk at each time interval are shown below curves. Standard error was  $\pm 0.12$  or better at all data points.

allow for some extra room for thrombus lining or intimal hyperplasia that may occur with time. After a high incidence rate of rapid ostial stenosis development at the iliac-caval junction when the stent was restricted to the iliac vein,<sup>9</sup> we made a routine practice of extending the stent for 2 to 3 cm into the cava, eliminating this problem. In more than 500 stent implantations, contralateral flow compro-

mise has not been a significant problem with this practice, even in cases of ipsilateral stent occlusion (Fig 6). Our earlier conservatism in tending to choose the shortest stent length possible led to development of stenotic lesions in partially diseased adjacent venous segments. This led to a policy of a more aggressive approach of covering all contiguous diseased segments without short skip areas if practical.



**Fig 6.** Extension of stent for 2 to 3 cm into cava prevents stenosis development at ilio caval junction after recanalization and does not impede contralateral outflow as shown.

Most stents have been extended to the common femoral vein to satisfy this principle. Stent fracture or wall erosion (false aneurysm, arteriovenous fistula) was not seen in this experience. Crossing the inguinal ligament (Fig 7) appears not to have had an adverse effect on stent patency, at least in the short term. This is probably related to the exclusive use of flexible stents that can bend without lumen compromise. We have not placed stents in the superficial femoral vein because the profunda femoris vein provides adequate inflow and the reported experience of superficial femoral vein stent placement has been relatively poor.<sup>11</sup>

The clinical efficacy of recanalization with stent placement in this subset of patients with advanced iliac venous disease has been impressive despite the presence of significant distal obstruction and reflux. It underscores the dominant role of the iliac venous segment in the genesis of postthrombotic syndrome. Complete pain resolution occurred in most patients, with significant improvement in others. The analogue scale technique used in this report,



**Fig 7.** Crossing inguinal ligament or long stent length did not appear to affect patency. Note long stent extending from common femoral vein to mid inferior vena cava.

although subjective, is widely used and has been validated<sup>4</sup> as a reliable standard in outcome measurement.

Swelling results in this study are understated. For example, three patients became ambulatory from previous wheelchair confinement, and in others, whole limb swelling receded to more limited swelling below the knee after recanalization. Yet the objective classification of limb swelling remained the same (grade 3) before and after the stent placement and the swelling outcome was marked as unchanged. Total resolution of swelling did occur in about a third of patients after recanalization. Actuarial healing of ulcers/stasis dermatitis in 66% at 1 year was noteworthy because stasis skin changes and ulceration are generally attributed to reflux not obstruction. Uncorrected residual reflux (multisegment<sup>12</sup>) (Table II) persisted in these limbs after the stent procedure.

Of note, swelling was absent in 22% of the patients despite occluded iliac veins. Some patients were first seen with pain alone without any other outward signs of iliac occlusion; clinical features in others would have suggested reflux, not obstruction (Table I). This varied and sometimes deceptive presentation masking the underlying iliac venous occlusion argues for comprehensive investigation of patients without preconceived notions regarding underlying pathology. Duplex scan is being increasingly used both as a screening and a sole diagnostic technique in chronic venous insufficiency. It is not well suited to assessment of



the iliac venous segment, and an occlusive or stenotic lesion is easily missed.

Clinical efficacy, disappearance of collaterals, and improvement in intraoperative femoral vein pressures (Table II) indicate that tangible hemodynamic benefit resulted from the stent procedure. Yet this was not reflected in any of the postoperative functional studies, including arm/foot venous pressure differential, undertaken in this group of patients (Table II). The latter test has been considered the most reliable among the currently available tests for venous obstruction.<sup>13</sup> Outflow fraction measurements are even less reliable.<sup>14-16</sup> We conclude that all functional tests of obstruction currently available lack sensitivity. It was of note, however, that reflux as measured with venous filling index<sub>90</sub> (VFI<sub>90</sub>) with airplethysmography and multisegment reflux score<sup>12</sup> with duplex scan did not worsen after recanalization (Table II). Chronic iliac venous occlusion was not "protective" of reflux, and opening up the axial channel did not lead to a worsening.

The median follow-up time frame for this series of patients was 11 months. In the smaller number of patients followed up to 3 years or more, clinical efficacy and stent patency appear to have been maintained without signs of precipitous deterioration. Reported experience with venovenous bypass procedures had been highly variable with regard to bypass patency and clinical efficacy<sup>16-18</sup>; in several such series, the results had declined below those reported here for stents at a comparable time frame. The high technical and clinical success of stent technology as used in this study and its relative simplicity (percutaneous procedure, 23-hour admit) would appear to render traditional open venovenous bypass techniques obsolete except as a backup procedure in patients with failed stent placement. Placement of stents does not preclude subsequent open technique in case of stent failure.

## REFERENCES

1. Hurst DR, Forauer AR, Bloom JR, Greenfield LJ, Wakefield TW, Williams DM. Diagnosis and endovascular treatment of ilioacaval compression syndrome. *J Vasc Surg* 2001;34:106-13.
2. Raju S, Owen S Jr, Neglen P. The clinical impact of iliac venous stents in the management of chronic venous insufficiency. *J Vasc Surg* 2002; 35:8-15.
3. Kistner RL, Eklof B, Masuda EM. Diagnosis of chronic venous disease of the lower extremities: the "CEAP" classification [review]. *Mayo Clin Proc* 1996;71:338-45.
4. Scott J, Huskisson EC. Graphic presentation of pain. *Pain* 1976;2:175-84.
5. Launois R, Rebpi-Marty J, Henry B. Construction and validation of a quality of life questionnaire in chronic lower limb venous insufficiency (CIVIQ). *Qual Life Res* 1996;5:539-54.
6. Illig KA, Ouriel K, DeWeese JA, Riggs P, Green RM. Increasing the sensitivity of the diagnosis of chronic venous obstruction. *J Vasc Surg* 1996;24:176-8.
7. Murphy TP, Marks MJ, Webb MS. Use of a curved needle for true lumen re-entry during subintimal iliac artery revascularization. *J Vasc Interv Radiol* 1997;8:633-6.
8. Neglen P, Berry MA, Raju S. Endovascular surgery in the treatment of chronic primary and post-thrombotic iliac vein obstruction. *Eur J Vasc Endovasc Surg* 2000;20:560-71.
9. Neglen P, Raju S. Balloon dilation and placement of venous stent in chronic iliac vein obstruction: technical aspects and early clinical outcome. *J Endovasc Ther* 2000;7:79-91.
10. Neglen P, Raju S. Intravascular ultrasound (IVUS) evaluation of the obstructed vein. *J Vasc Surg*. In press 2002.
11. Mewissen MW, Seabrook GR, Meissner MH, Cynamon J, Labropoulos N, Haughton SH. Catheter-directed thrombolysis for lower extremity deep venous thrombosis: report of a national multicenter registry. *Radiology* 1999;211:39-49.
12. Neglén P, Raju S. A rational approach to detect significant reflux using duplex Doppler scan and aeroplethysmography. *J Vasc Surg* 1993;17: 590.
13. Neglén P, Raju S. Detection of outflow obstruction in chronic venous insufficiency. *J Vasc Surg* 1993;17:583.
14. Neglén P, Raju S. Compliance of the normal and post-thrombotic calf. *J Cardiovasc Surg* 1995;36:219.
15. Labropoulos N, Volteas N, Leon M, Sowade O, Rulo A, Giannoukas AD, et al. The role of venous outflow obstruction in patients with chronic venous dysfunction. *Arch Surg* 1997;132:46-51.
16. Halliday P, Harris J, May J. Femoro-femoral crossover grafts (Palma operation): a long term follow up study. In: Bergan KK, Yao JST, editors. *Surgery of the veins*. Orlando: Grune & Stratton; 1985. p. 241-54.
17. Eklof BG, Kistner RL, Masuda EM. Venous bypass and valve reconstruction: long term efficacy. *Vasc Med* 1998;3:157-64.
18. Raju S. New approaches to the diagnosis and treatment of venous obstruction. *J Vasc Surg* 1986;4:42.

Submitted Feb 28, 2002; accepted May 27, 2002.